

The Future of Europa Exploration

Our curiosity with Europa has been only partially satisfied by the Galileo mission. In fact, the more answers we looked for, the more questions we found. The extension of the mission for two years (Galileo Europa Mission) shows just how intrigued we are by Europa. Fascinating images and unique data returned from the spacecraft have contributed greatly to our understanding of the moon, although what we have now is merely a snapshot compared to what we would like to know. To unravel the mysteries of Europa and complete the picture, we will need to target the icy moon for exploration once again.

Space exploration advances in a series of small steps, each directed by the questions yet unanswered, and designed with the technology available at the time of launch. One of the key questions scientists have been debating is how long it has been since Europa was geologically active. The lack of significant cratering suggests the moon's surface might be very young, although we know very little about cratering rates in the Jovian system. Another intriguing hypothesis about Europa is that heat generated through tidal flexing may have created a liquid ocean beneath the moon's icy crust. Although it is Galileo's instruments that have allowed us to see these possibilities, the nature of the current mission, with the spacecraft flying past Europa for only a few hours at a time, prevents us from gathering conclusive evidence.

Scientists are currently discussing the types of missions that would best answer their questions. One idea is to send a spacecraft that would remain in orbit above Europa. Given the high levels of radiation near Jupiter, an orbiter would survive no more than about one month. During that time, however, it would take continuous measurements of the moon's surface, atmosphere, and magnetic field. Using a technique called laser altimetry, an orbiter would measure very small changes in Europa's shape as the moon circles Jupiter. If the crust is solid ice, tidal changes through a complete 3-day orbit will be very small, perhaps only a few centimeters. On the other hand, if the surface of Europa rises and falls on the order of several tens of meters, we would have compelling evidence that a liquid ocean exists beneath the surface.

Scientists would also like to know the structure of Europa's interior. They might equip an orbiter with radar to look through the ice and determine how the crust changes with depth. The crust may be uniform in thickness and density from top to bottom, it may change abruptly from ice to water, or may show a gradual transition from hard ice to "soft" ice to liquid water. As an orbiter flies overhead, it might also measure how much Europa is pulling on the spacecraft at different locations. The amount of "pull" at each location depends on the mass between the surface and the center of the moon. By comparing this gravity data from many different locations, scientists could construct a 3-D view of the interior of the moon.

Galileo's instruments have shown us that the physical properties of water ice vary from place to place on the surface, but we still know very little about the source and

composition of the reddish-brown material that covers much of the landscape. It may have been brought to the surface through the many cracks in the ice, or could be material derived from objects that have impacted the surface. It may even contain organic compounds. Some scientists have suggested sending a lander or rover to collect and analyze samples directly on the surface using an instrument such as a mass spectrometer. A lander or rover could also measure and pinpoint any seismic activity which might be occurring if Europa is geologically active today.

If an ocean does indeed exist beneath Europa's crust, how might we explore it? One suggestion is to send a robotic probe that could bore through the ice, and then release a remotely controlled miniature submarine equipped with lights and cameras. Scientists are currently developing prototypes of such robotic explorers for use in such places as ice-covered lakes in the Antarctic.

Ideas like these are being discussed by scientists and engineers as they strive to answer some of the most compelling questions about mysterious Europa. Each proposal, and the many others that are sure to come, will be evaluated on its merits and feasibility, and perhaps one of them will be selected as our next Europa mission. Remember, also, that space exploration is for all humanity. What do you want to know about Europa, and how would your questions be answered best? What new technologies can you imagine developing in the next millennium that might be used for exploration of Europa? Depending on the answers you give, the chosen mission might be very different from those outlined above.